Two Axis Solar System

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Abstract

For several hours of service, stationary solar energy systems produce less than their maximum power output. This is because solar panels produce their highest peak power while they are perpendicular to the sun's light, which occurs only for a brief period of time during the day while the panel is stationary. Solar tracking systems have been around for a long time and solve this problem. Some systems use light sensor arrays to monitor the sun's light intensity, while others depend on mathematical models with no external sensors that simply set the angle of the panel at specific times during the day. This project's engineering design phase is split into two semesters, with the first semester's design process having already been detailed in the first article. The aim of this document is to show how to develop, test, and analyse a low-cost solar tracking system primary design that best addresses the problem statement.

Description: Humanity has created a massive dependence on energy as a result of exponential technological development. Energy generation has risen to the top of society's priority list. The solar cell was created in an effort to increase energy availability. A solar cell is a system that uses the photovoltaic effect to transform light energy directly into electricity.

Motivation: The project was inspired by the social significance of solar energy. Solar panels, for example, must be used to their full capacity in the face of a global energy crisis. As a result, methods that can maximise their energy collection are in high demand. Solar monitoring systems are one of these techniques. In the last decade, these devices have become more widely used, resulting in a variety of tracking systems.

Keywords: Solar Panel, Arduino, Solar Power

Introduction

Function Statement: A system is needed to change the vertical and horizontal position of a solar panel in order for it to remain perpendicular to direct sunlight. As a result, it can produce more energy than a traditional fixed solar panel.
Design Requirements: Construction of device shall not exceed the $500 in pricing. The Panel needs to maintain a perpendicular (90 degree) angle with direct sunlight, with a 1-3% tolerance. The azimuthal axis needs to have a range of 180 degrees of rotation from any position. An altitudinal axis provides an angle of declination of at least 45 degrees. The system should absorb 25% more energy than a fixed solar panel.
Scope: There will be four major components to the project. The solar panel is the device's pillar, and it will be fixed and placed above the base to increase the device's stability and structural competence. Many of the other components would be stable because of the base. Two drivers will be mounted between the foundation and the solar panel: a stepper motor and a linear actuator. Either driver will be in control of a vertical or horizontal axis.
Benchmark: There are a plethora of solar trackers on the market, as well as a number of others that have been developed through academic research and will be directly related to the previous Solar Tracker developed by other engineers.
Project Success: The device's ability to sense and adapt to the perpendicular angle with a tolerance of 5-10% and consume at least 10% more energy than the fixed solar panel would determine the project's true success.

Working Principle/Calculation

An external interrupt was set up to change a "mode" variable whenever a button was pressed within the circuitry. This variable controlled whether the system was in tracking mode or user input mode in the rest of the code.The numerical difference between the two variables that were transferred to PWM was used to regulate the motor's speed (either the two angles or the two photoresistor voltages). Equation 1 shows the speed scaling formula which was used. This equation always yields a number between 0 and 75. The max value of the PWM output is 255 which would result in a 100% duty cycle.

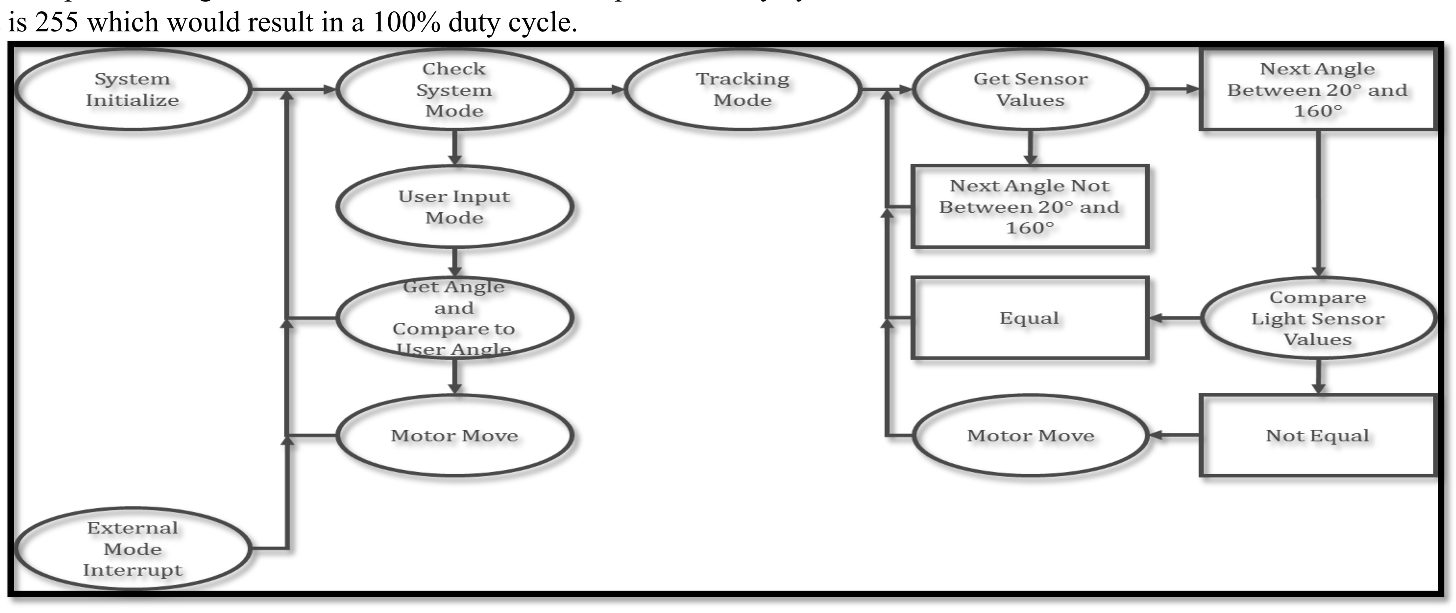


Figure 1 Working Principal

Equation 1
$$scale = 75 * \frac{abs(comp2 - comp1)}{\max(comp1, comp2)}$$

An if statement clause was added to the motor control function that ensured that the PWM scale value did not drop below 30 as the motor would not operate well below this scaling factor. Then another if statement was used to determine which of the motor driver input pins would be grounded and which would have the PWM voltage applied to them by comparing the two input voltages and then sending an signal to the motor driver to enable it. This would determine in which the direction the motor would operate.

Block and Circuit Diagram

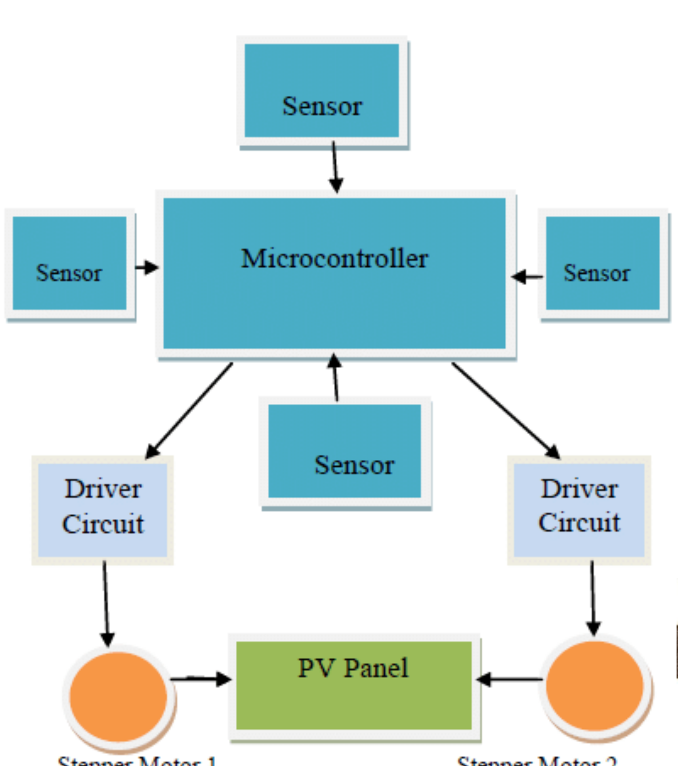


Figure 2 Block Diagram

The microcontroller, a motor driver, two light sensors, and an accelerometer are the components of the circuit diagram shown in Figure 3 below. The sensors are powered by a 5V voltage controlled power supply on the microcontroller. Using the analogue inputs, the Arduino microcontroller reads the voltage at the voltage divider circuit. Based on the voltage difference, it sends a scaled PWM (Pulse Width Modulated) signal to the motor driver through the PWM enabled digital I/O pins. These PWM signals are used by the motor driver to control the DC motor's output speed and direction.

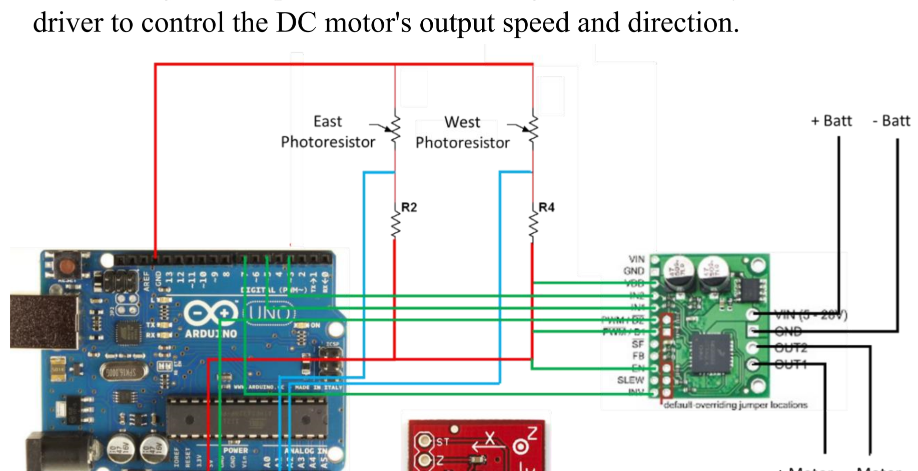


Figure 3 Circuit Diagram

The algorithm begins by collecting data from sensors. The analogue signals from the sensors are translated to digital signals. Analogue to digital converters are used to complete this mission (ADC). The microcontroller receives the digitised signals. It determines the movement direction and step angle of stepper motors after collecting digitised signals. The controller algorithm demonstrates that the microcontroller can only drive stepper motors if the sensor light sensing is not equal and the sensor signals are equal. It returns to the beginning of the algorithm. This process is repeated until the amount of light falling on the sensor pairs is equal, and the PV panel is positioned for maximum power. Solar panels produce varying voltages, which must be controlled. After the solar panel, a regulator may be used to control the voltage produced by the solar panel. The tracker circuitry needs power to operate, and this is provided by solar energy generated on site. Since no external power supply is needed, our system is both economical and cost efficient. By incorporating battery capacity and proper storage device control, the purposed model can also be used as a stand-alone system. The created voltage is used to power battery storage. The induced voltage is used to determine storage charging and discharging events.

Concept Design

The proposed smart DAST's specialty is active, which means that the movement of the solar tracker is determined instantly based on the location of the sun. To sense the position of the sun, four photo resistors LDRs (Cds GL5528) are used. The four locations of the sensors, which cover the entire area of the PV plate, give this design an advantage over others. As a result, when the sunlight intensity on the top LDRs equals that on the bottom LDRs and the intensity on the left LDRs equals that on the right LDRs, we can ensure that the PV panel is perpendicular to the sunbeam.

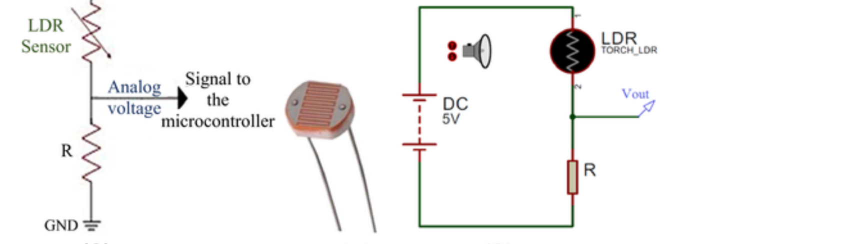


Figure 4 LDR Circuit

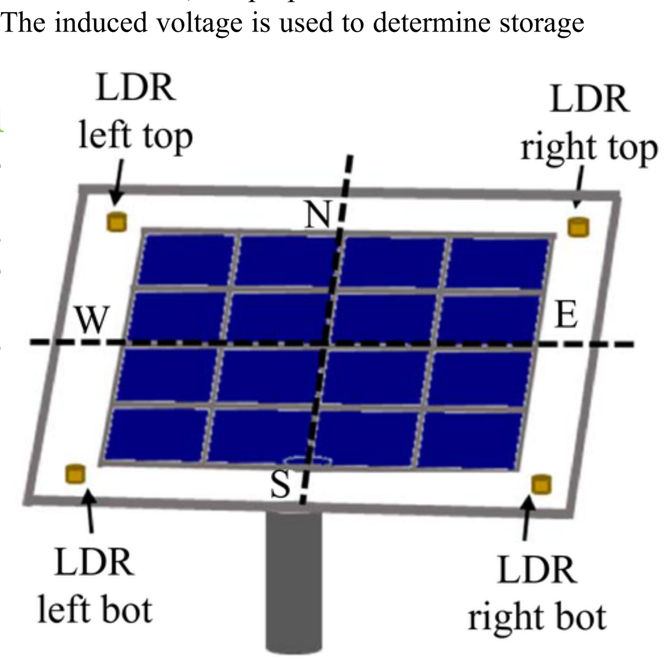
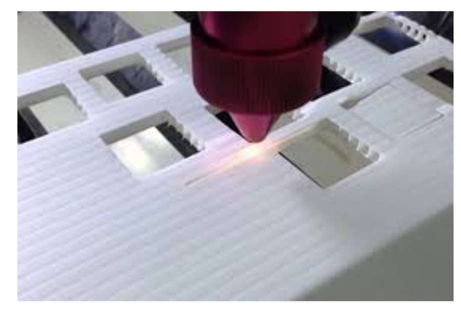
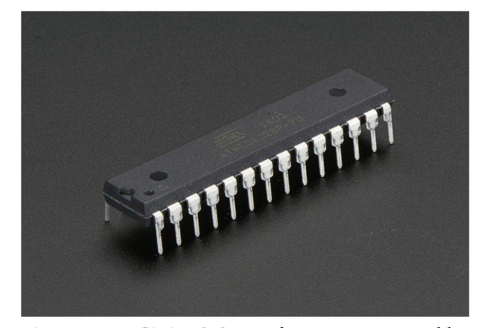


Figure 4 Concept Design

Device Fabrication & Components



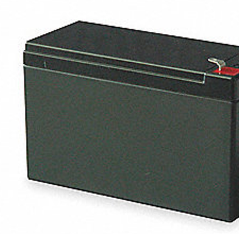
Laser Cut Acrylic Plastic



ATMEGA 32 Microcontroller

Servo motors

Solar Panel



12 V Battery

Design

This solar tracker control device measures light from the east and west (left and right) sides of the solar panel to decide which way the panel should be moved to point it directly at the source of the light. The panel tracker is controlled by a servo, which comes in a variety of sizes and can be scaled to fit your panel size. Despite the fact that this tracker is only one axis, the two sensors and servo can easily be duplicated to provide dual axis control.

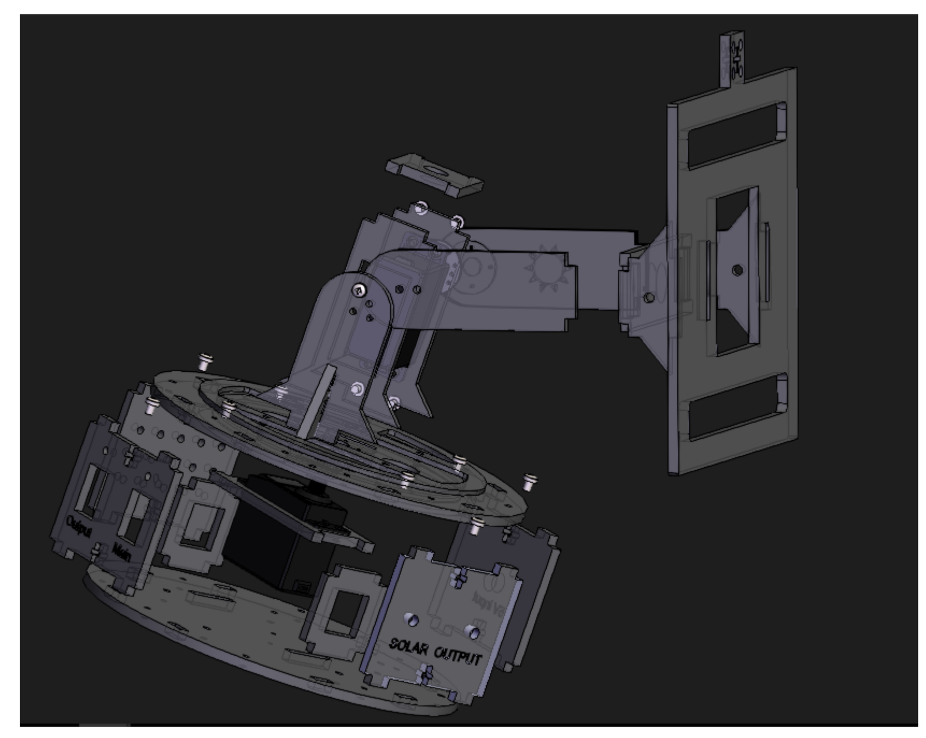


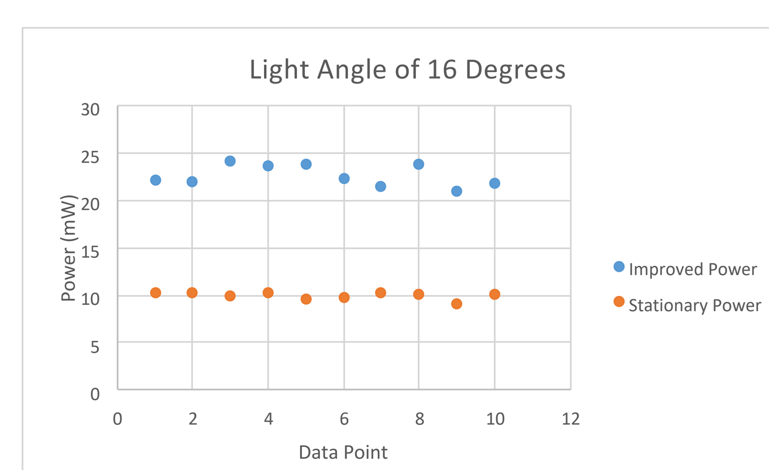
Figure 5 3D Design Exploded View

Testing and Analysis

The first requirement that the prototype had to meet is that the platform must be able to pivot to the point with the most solar light intensity, from any position, in less than 60 seconds. In order to meet this requirement, the platform must travel an angle of 120° in 60 seconds, which is 2° a second. This requirement was tested by measuring the time it took the platform to travel from one extreme to the other in a light controlled environment (to simulate the rise of the sun when the platform is at the sunset position). The software limited the solar panel angles of operation from 20° to 160°. The system was tested using the user input mode, telling the panel to go to 160° when it was already at the 20° position. The time to pivot from the first extreme to the second extreme was measured with a stopwatch at 15.86 seconds, which is well below the max allowable time of 60 seconds.

Figure 6: Ammeter Display of Current Draw under Maximum Load

Figure 7: Ammeter Display of Current Draw when System is Idle



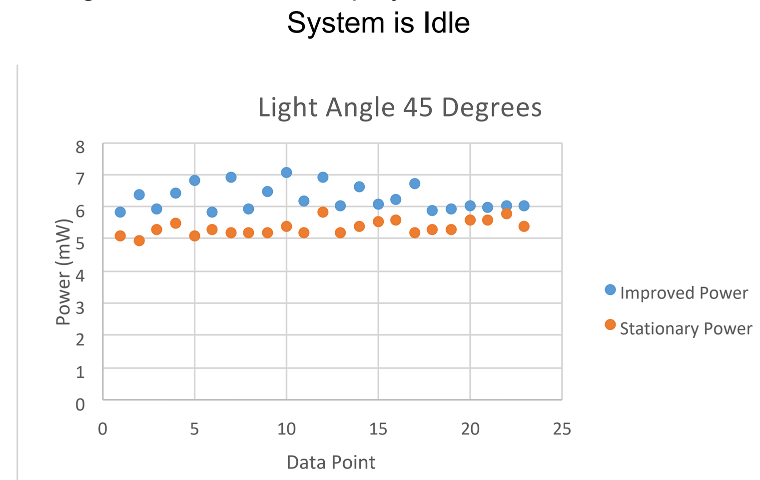


Figure 8 show the difference in power between the power outputs of the solar panel when the system was in stationary mode (set at 90°) compared to when the tracking system was on.

Figure 9 details the difference between the two systems when the light source was positioned at 45°. The average increase of power due to the tracking system was around 17% compared to the output of the stationary panel at 90°.

Project Goals

The prototype in the simulation meets all of the design requirements and specifications that were outlined. At the maximum speed of rotation, the solar panel was able to pivot from one extreme at 20° to the other extreme at 160° in 15.86 seconds. This meets the requirement that it travel that distance in less than 60 seconds. The control system's power consumption when it is idle is around 60mA which exceeds the maximum allowable power consumption of the system while it is in power saving mode of 94mA.

Conclusion

To highlight the challenges that we faced during the building process, the team faced a lot of difficulties in figuring out the mechanical system algorithm and the way to build it so it meets the requirements. As a result of this one change in the design was taken into consideration which is the use of the laser cut frame material that is lighter and much easier to use than the normal metal frame parts. It is also recommended that the photoresistors be encased in light proof material which would only allow light in from a more pointed direction. This would theoretically increase the accuracy of the system by blocking out incident light rays and focusing more on brighter light sources.

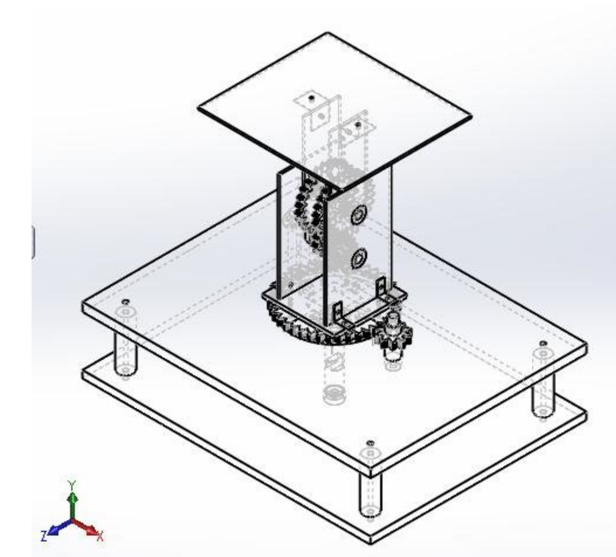


Figure 9 Isometric View of the design

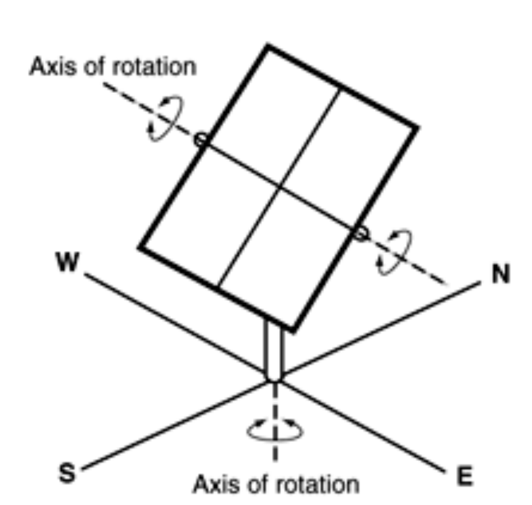


Figure 10 PV Array system depicting rotation

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